LQ search in e□jj channel

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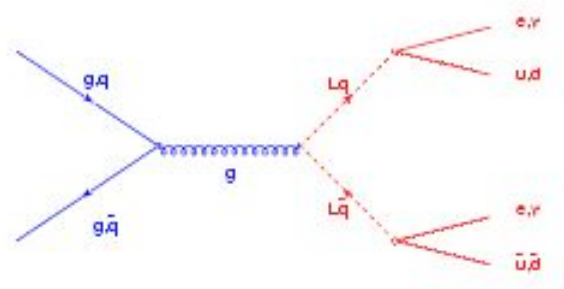
-Pre Blessing-

Introduction

- This analysis is an update of the result produced in June 2003
- REMAKE data 4.11.1 up to Summer shutdown used - 203 pb^{-1}
- New treatment of efficiencies
  - ID efficiencies used in MC and scaled to data
- New good run list
- Revised final selection cut
  - New MET cut raised at 35 GeV
  - New cut around the nominal LQ mass

LQ production at the TeVatron

- Production
  - qg → LQ + LQbar
  - gg → LQ + LQbar
  - qqbar → LQ + LQbar



- Decay
  - LQLQ → l^+l^-qq, $l^\pm\nu qq$, $\nu\nu qq$

β = Br(LQ->eq)

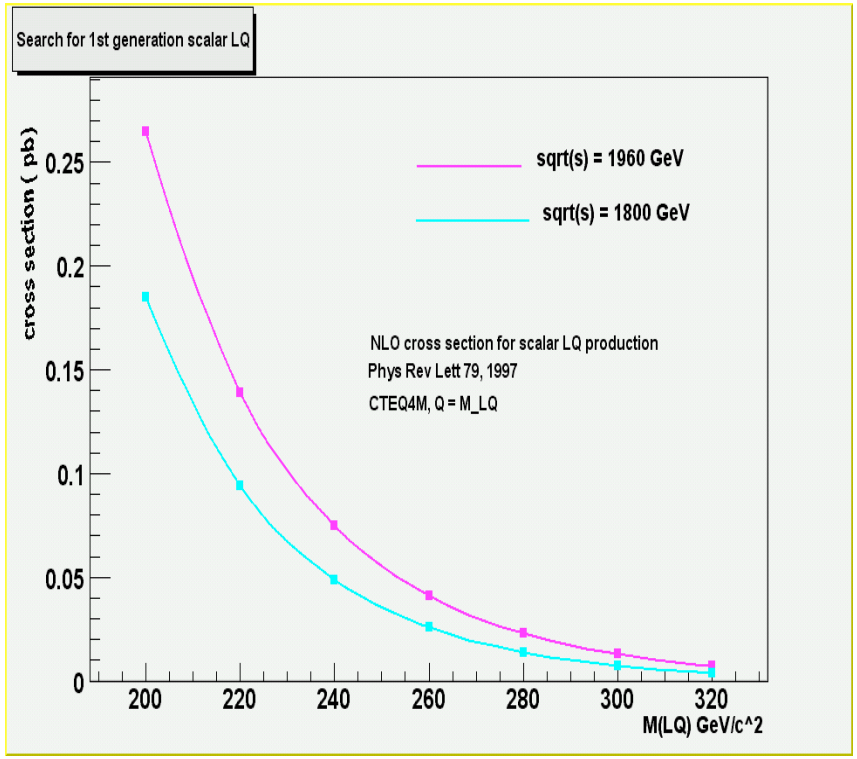
- Experimental signature:
  - High pt isolated leptons (and/or MET) + jets

In this analysis: e β + 2 jets

LQ production at TeVatron

NLO cross-section (Phys.Rev.Lett 79,1997)

M_{LQ} (GeV/c^2)	(NLO) [pb]
200	0.265E+00
220	0.139E+00
240	0.749E-01
260	0.412E-01
280	0.229E-01
300	0.129E-01
320	0.727E-02



$\sqrt{s}$ = 1960 GeV

$Q^2 = M_{LQ}^2$

CTEQ4M pdf

Previous results

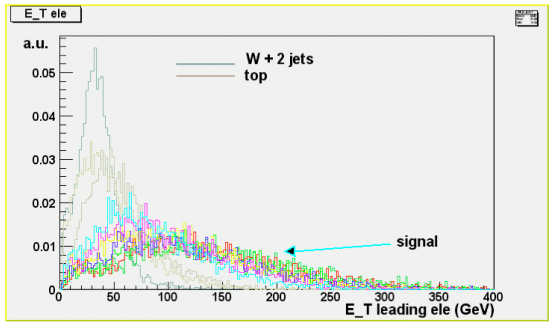
- CdfNote 6436 - June 2003
  - M(LQ) > 166 GeV/c^2
    - No Mass Cut but MetSig cut
- Cdfnote 4228 - July 1997
  - m(LQ) > 180 GeV/c^2
    - straightforward strategy
      - cut on transverse mass to get rid of W + 2 jets background
- Cdfnote 4873 - June 2001
  - m(LQ) > 182 GeV/c^2
    - relative likelihood technique

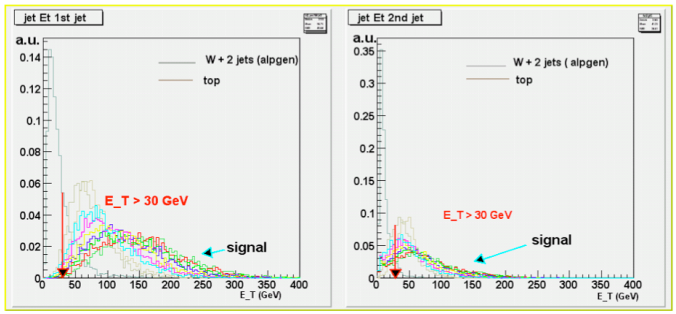
LQ search in e□jj

Signature: 1 electron, 2 jets and large MET

Analysis cuts

- 1central electrons with E_T > 25 GeV
- MET > 60 GeV
- Veto on 2nd electron, central loose or Plug
- 2 jets with E_T > 30 GeV
- □□ (MET-jet) > 10°
- $E_T(j1) + E_T(j2)$ > 80 GeV
- $M_T(e\text{-}□)$ > 120
- LQ mass combinations





Events with 2 central/plug electrons are rejected (to be orthogonal to eejj analysis)

New MET cut

The Missing Et cut has been raised to 60 GeV

Background reduced by a factor ≥2 (top, W + 2 jets)
Signal stays the same

M(LQ)	140	200	280
E_T > 35	0.08 ± 0.01	0.17 ± 0.01	0.26 ± 0.006
E_T > 60	0.07 ± 0.01	0.16 ± 0.01	0.25 ± 0.006

Top

2.5	3.08	2.9	2.6	2.3	1.8	1.5	1.0	0.7	0.6
4.0	5.0	5.2	4.8	4.2	3.6	3.2	2.2	1.6	1.2

W+ 2 jets

1.5	5.5
1.5	9.5
1.5	9.9
2.5	10.5
2.5	10.
2.5	9.0
2.0	8.0
2.0	7.0
1.5	5.5
0.5	3.5

Other Cuts Efficiency

We studied the effect of 5 cuts on signal (m(LQ) = 200 GeV/c^2) and W + 2 jets and Top (main background)

Analysis of the signal and background reduction by applying all but one cut (N-1)

	Signal	W + 2jets	Top
P_T ele > 25	14.77	16200	113.8
MET > 60 GeV	6.5	22	7.8
2 jets with E_T > 30 GeV	7.8	20.5	6.2
□□ (MET-jet) > 10°	6.2	5	5.3
E_T(j1) + E_T(j2) > 80 GeV	5.9	3.5	5.0
M_T(e-□) > 120	7.1	64.5	22.06
After all cuts in sequence	5.8	3.0	4.82

Tools

- Signal generated and reprocessed with 4.9.1
  - 5000 events at masses from 100 to 280
    - run number 151435
    - full beam position
      - talk GenPrimVert
      - BeamlineFromDB set false
      - sigma_x set 0.0025
      - sigma_y set 0.0025
      - sigma_z set 28.0
      - pv_central_x set -0.064
      - pv_central_y set 0.310
      - pv_central_z set 2.5
      - pv_slope_dxdz set -0.00021
      - pv_slope_dydz set 0.00031
      - exit
- eN (4.9.1)used for ntuple analysis
  - http://ncdf70.fnal.gov:8001/talks/eN/eN.html

Efficiencies & acceptance

$$\varepsilon_{tot} = \varepsilon_{Acc}(M) \times \varepsilon^{data}_{ID} / \varepsilon^{MC}_{ID} \times \varepsilon_{z0} \times \varepsilon_{trig}$$

- Trigger
  - Top/EW - as in Z` analysis we use 99.1±0.1%
- Efficiencies for electron selection cuts
  - Z' analysis : one tight electron

    ε_T = 94.5 ± 0.2
- Other
  - eff. on the vertex cut ($|z_0|$ < 60 cm)95.2 ± 0.1 (stat) ± 0.5 (sys)

Kinematical and geometrical acceptance

- Events are selected where the electron satisfies the tight requirements of the exotic group. The analysis (kinematical) cuts are then applied.

Central electron tight

- $E_t \geq 25$ GeV
- $p_t > 15$ GeV
- hadem <= 0.055 + 0.00045 * E
- E/p < 4 (for $E_T < 100$ GeV)
- iso4e/emet < 0.1
- |DeltaX | < 3.0
- | DeltaZ | < 5.0 cm
- Fiducial = 1
- lshr < 0.2

HEPG electrons are then matched in a $\Delta R = (\Delta\eta^2 - \Delta\phi^2)$ cone to the reconstructed electron :

ID efficiencies are calculated on them scale factor to data is derived: $\varepsilon^{data}/\varepsilon^{MC}$

the events surviving the final kinematical cuts are normalized to the number of matching electrons;

Acceptances - numbers

Cuts	Cdf 6746	W + 2 jets	m(LQ) = 200
Iso < 0.1	97.2 ±0.2	95.7 ±0.2	95.7 ±0.2
Had/EM	99.0 ±0.1	99.9 ±0.2	99.5 ±0.2
E/P	99.0 ±0.1	97.29 ±0.2	96.8 ±0.2
Dx	98.9 ±0.1	98.9 ±0.2	98.4 ±0.2
Dz	99.7 ±0.1	99.3 ±0.2	98.9 ±0.2
lshr	98.7 ±0.1	98.6 ±0.2	98.9 ±0.2
$\not\!\!E_T$	94.5 ±0.2	89.9 ±0.2	88.1 ±0.2

Efficiency of the ID cuts for central electrons - individual cuts

MetSig Cut Removal

The E_T significance cut is not optimal:

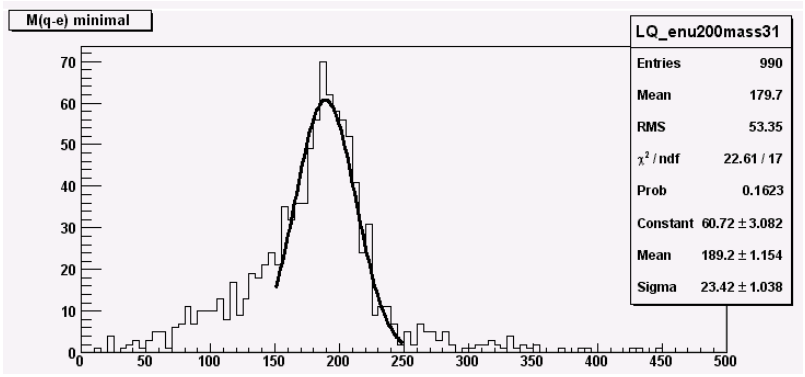
- large systematic associated due to mis-modeling of Sumet in MC
- Sumet is generally smaller in MC
  - "overefficiency" in MC : for the same MET, Metsig is smaller in data

Mass Cut is used instead of Missing Et significance

- It was used in Run I
- Signal efficiency acceptable (same as Metsig cut)
  Powerful background constrain, better controlled as function of LQ mass
  BETTER LIMIT !

Mass Cut

The invariant mass of the electron-jet system and the transverse mass of the neutrino-jet system are selected where the jet assignment is made such that the difference between the electron-jet mass and the neutrino-jet transverse mass is minimized.



The peak of the *ej* histogram is fitted with a gaussian

rough estimate of the spread of the distribution in the signal region.

Several masses (120-160-200-240-280) tested:

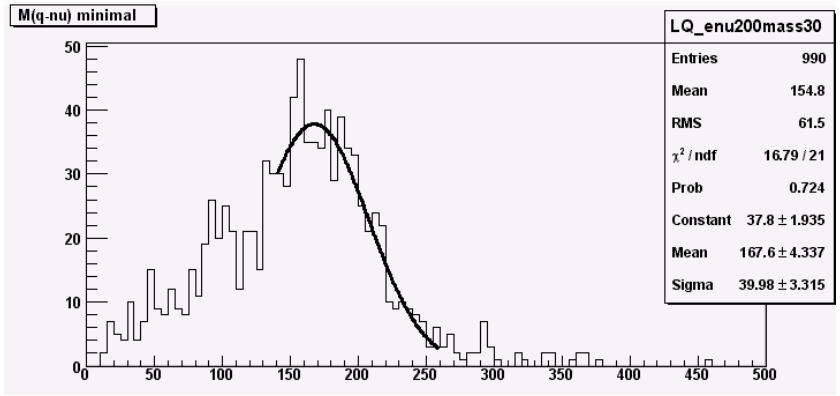
$\sigma_e \sim 15\%$.

$3\sigma_e$ cut around the nominal mass to select LQ candidates of a given mass.

Mass Cut (continued)

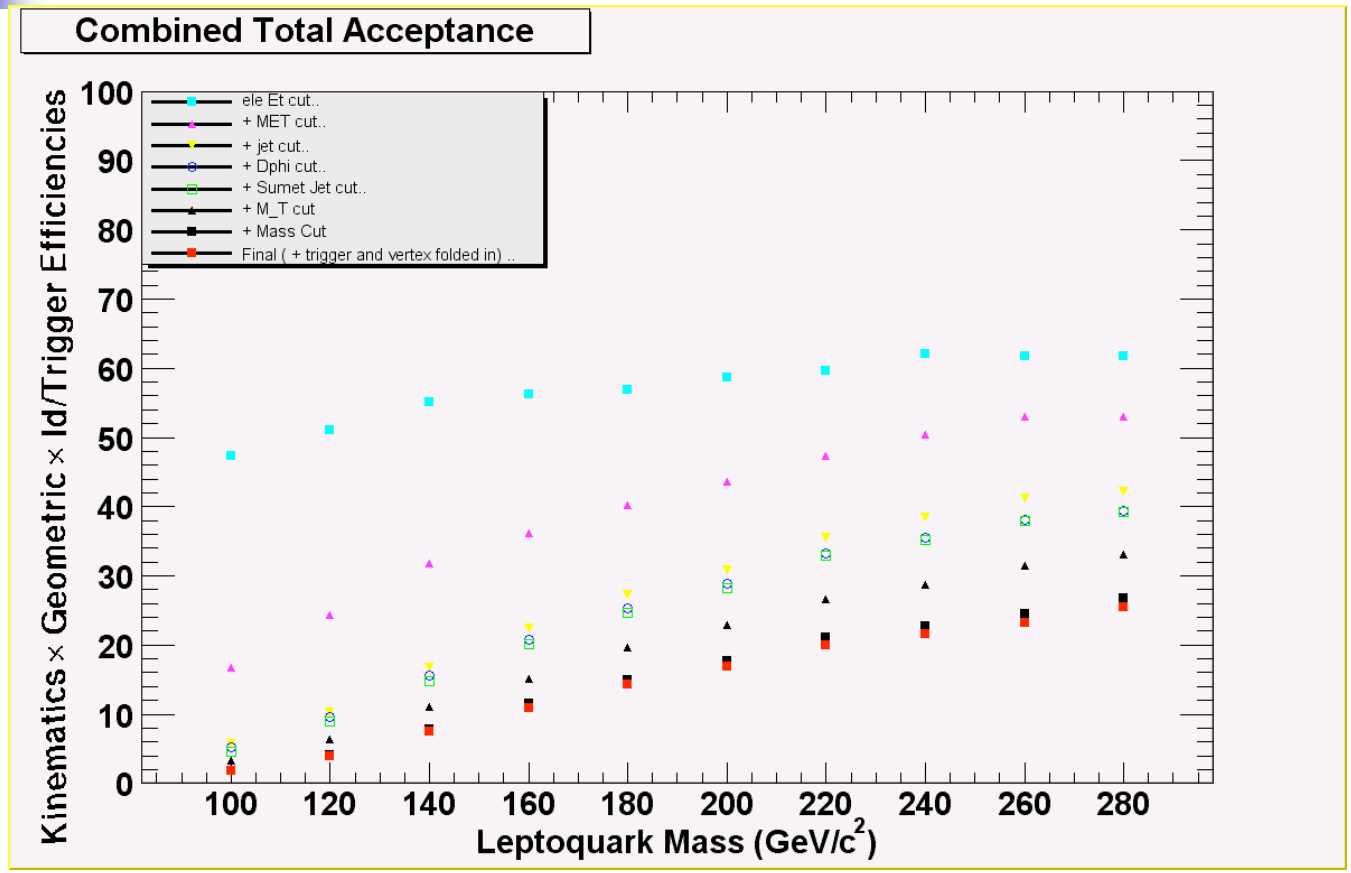
The *□-q* transverse mass distribution is fitted including the high mass tail end, with a Gaussian to estimate the signal spread. □□ ~ 25%.

Inefficiency at low end?
The region is more background populated…



3□□ cut applied around the nominal mass

Final Acceptances



Expected signal events

Mass	Theory CTEQ4M (pb)		
	$Q^2 = M^2/4$	$Q^2 = M^2$	$Q2 = 4M^2$
100	31	28	24.1
120	25	22.6	19.5
140	19.7	17.9	15.5
160	13.5	11.7	10.3
180	8.5	7.4	6.5
200	5.2	4.4	3.9
220	3.2	2.7	2.4
240	1.65	1.6	1.4
260	1.11	0.94	0.8
280	0.7	0.6	0.5

Number of expected events in 203 pb^{-1}

Backgrounds

Main background sources:
W + 2 jets
Z + 2 jets w/ mismeasured electron
Top
W(□ □□) + 2 jets - negligible

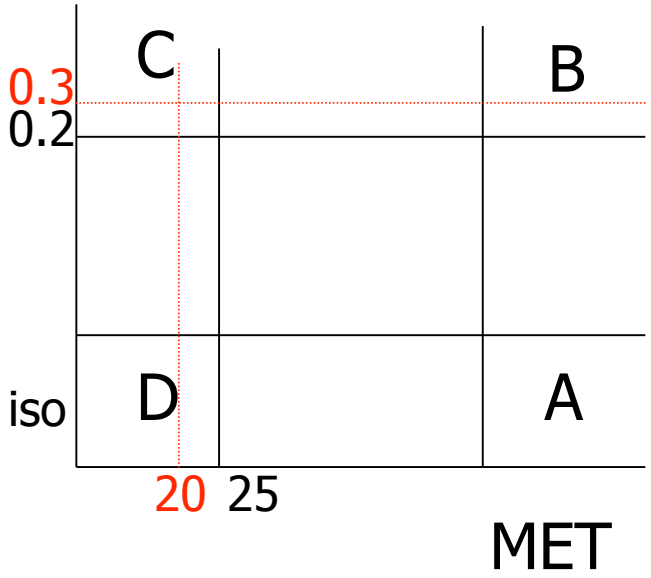
MC Alpgen
Pythia

atop02
atop2e
ttopei

QCD fakes - from data iso vs MET negligible

QCD background

Iso vs MET has been employed
2 sets of cuts



	A	B	C	D	Bgk
Lepton	1073	24	54239	81078	35.8
MET60	124	3	1649	1712	21.7
2 jets	104	2	1359	1382	2.03
□□	18	0	0	5	nan
M_T	7	0	0	0	nan

	A	B	C	D	Bgk
Lepton	1073	11	17863	71321	43.9
MET60	124	2	578	1485	5.3
2 jets	104	2	474	1204	5.08
□□	18	0	0	1	nan
M_T	7	0	0	0	nan

□□ cut removes it?

Negligible in first approximation

Check: relax the □□
Relax the ele E_t requirement

Data sample

- btop0g (inclusive electrons) stripped from bhel08 and (4.8.4 Production)
- Inclusive-ele_4.11.1_REMAKE
- events selected from Ele_18 && Ele_70 triggers
- good runs from March 2002 to September 2003 (141544 - 168889)
  - Good run list from DQM page, em_noSi version 4
    - Removed 4 runs due to CSL problem
    - Luminosity = 199.7 * 1.019 = 203.5 ±12.2
    - http://www-cdf.fnal.gov/internal/dqm/goodrun/v4/goodv4.html

W cross section

$\not{E}_T$ > 25 GeV

Relaxing the MET cut to 25 GeV we obtain 112384 candidate W events

We use the same numbers used CDF6681 (the background is scaled to the increased Luminosity) :

$$\sigma \cdot B(p\bar{p} \rightarrow W \rightarrow e\nu) = \frac{N_W - N_{BG}}{A_W \cdot \epsilon(Z_{vtx} < 60) \cdot \epsilon_c \cdot \epsilon_T \cdot \mathrm{R}_{COT} \cdot \mathrm{R}_{EMC} \cdot \int \mathcal{L}dt}$$

$$\begin{aligned}
N_{BG} &= 1656 \pm 52(stat) \pm 295(syst) \\
A_W &= (23.895 \pm 0.03(stat)^{+0.34}_{-0.39}(syst))\% \\
\epsilon(Z_{vtx} < 60) &= (95.0 \pm 0.2(stat) \pm 0.3(syst))\% \\
\epsilon_c &= (81.8 \pm 0.8(stat) \pm 0.2(syst))\% \\
\epsilon_T &= (96.6 \pm 0.1(stat))\% \\
R_{COT} &= (100.0 \pm 0.4)\% \\
R_{EMC} &= (99.8 \pm 0.4)\%
\end{aligned}$$

N_W = 112384
N_{BG} =1656 * 203/72
$\int \mathcal{L}dt$ = 203

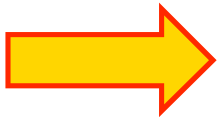
σ = $2.953 \pm 0.032_{stat} \pm 0.051_{sys} \pm 0.177_{lumi}$ nb

W cross section (cont'd)

We checked that we would get the
Same acceptance using W MC:
wewk9e (official EW group)

Acc = 0.213592 ± 0.0013 □ 94.5/89.8 = 22.4 ± 0.002

Our electron cuts are different: E/P in particular is relaxed
Running w/ E/P tightened gives 107385 evts observed



$\square = 2.816 \pm 0.31_{stat} \pm 0.049_{sys} \pm 0.168_{lumi}$ nb

W + 2 jets cross check

$\not\!\!E_T$ > 35 GeV

We checked the number of events we would expect after the 2 jets cut:

QCD background (corrected for sideband contributions) 38.5 ± 6
Top contribution 56 ± 8
Z + 2 jets contribution ~25 ± 3
W□ □□ contribution 16.6 ± 2.6

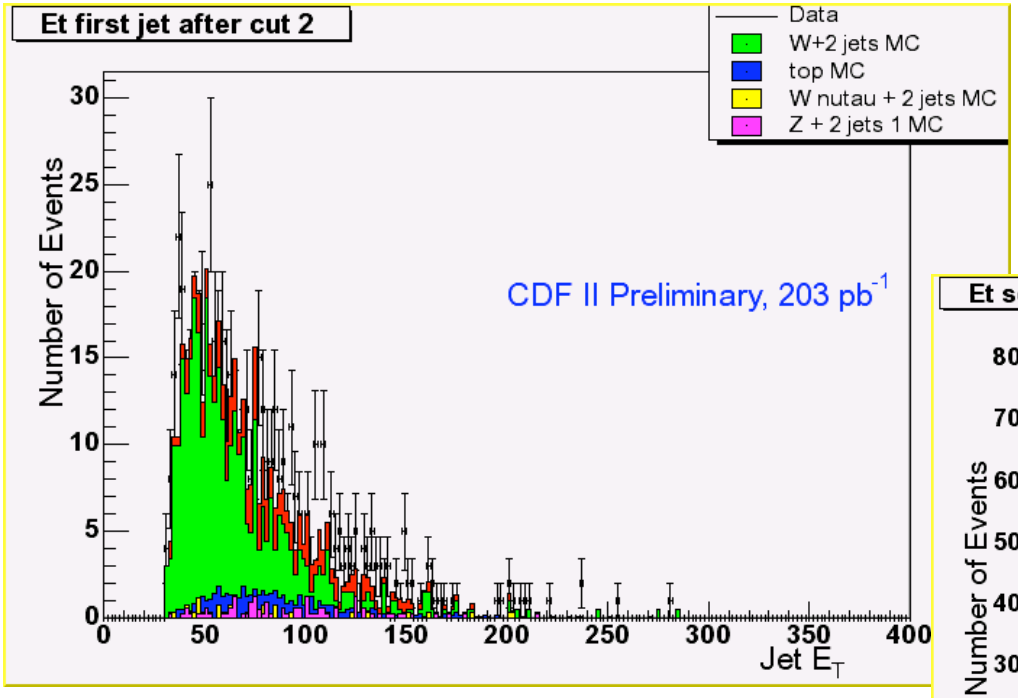
136.5 ± 20.4

~503

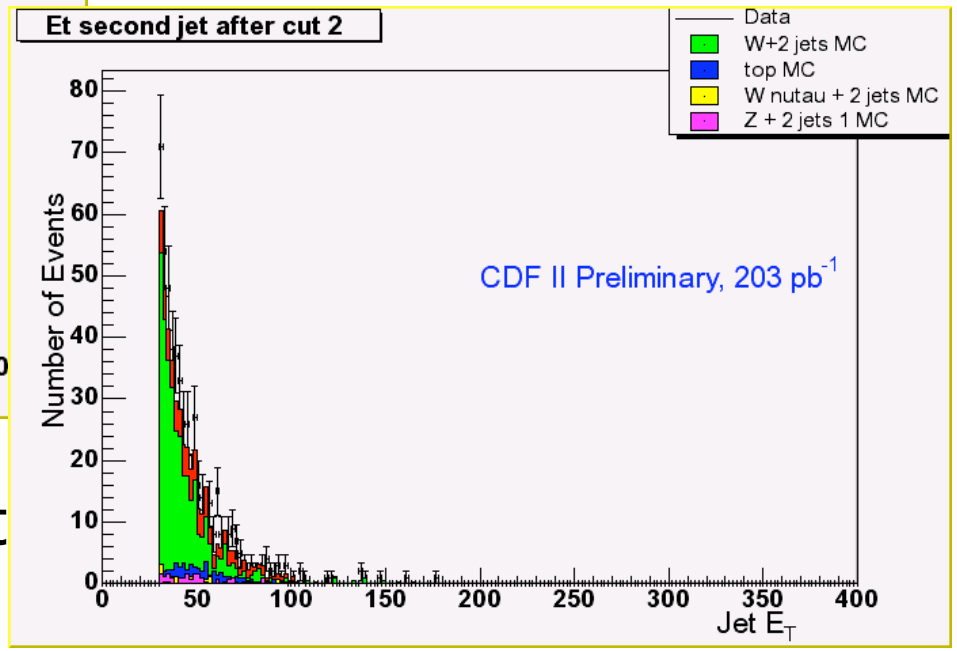
The number of expected W + 2 jets is 366 ± 17

We observe 536 events

W + 2 jets cross check



$\not\!\!E_T$ > 35 GeV



Jet E_T distributions after jets cut

Mass Cut (cont'd)

events with 1 ele > 25 && MET > 60 **1073**
events with 1 ele, MET and >= 2 jets (30 30) **125**
events with 1 ele, MET and >= 2 jets and dphi cut **104**
events with 1 ele, MET and >= 2 jets and dphi cut and 2jet_80 **95**
events with 1 ele, MET and >= 2 jets and dphi cut and 2jet_80 and T mass cut **18**

Mass	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**
W+2 jets	1.5±0.9	1.5±0.9	1.5±0.9	2.5±1.13	2.5±1.13	2.5±1.13	2.0±1.0	2.0±1.0	1.5±0.8	0.5±0.4
top	2.5 ±0.6	3.08 ±0.6	2.9 ±0.6	2.6 ±0.6	2.3 ±0.5	1.8 ±0.5	1.5 ±0.3	1.0 ±0.3	0.7 ±0.2	0.6 ±0.2
Z+jets	0.05 ±0.01	0.05±0.01	0.08±0.02	0.08±0.02	0.08±0.02	0.08±0.02	0.06±0.02	0.06±0.02	0.04±0.01	0.04±0.01
Total	4.2±3.8	4.65 ±4.3	4.5 ±4.0	5.16 ±4.3	4.85 ±4.0	4.47 ±3.8	3.6 ±3.2	3.1 ±2.8	2.3 ±2.1	1.1 ±1.1
Data	**7**	**7**	**6**	**6**	**4**	**4**	**4**	**2**	**2**	**1**

Systematic uncertainties

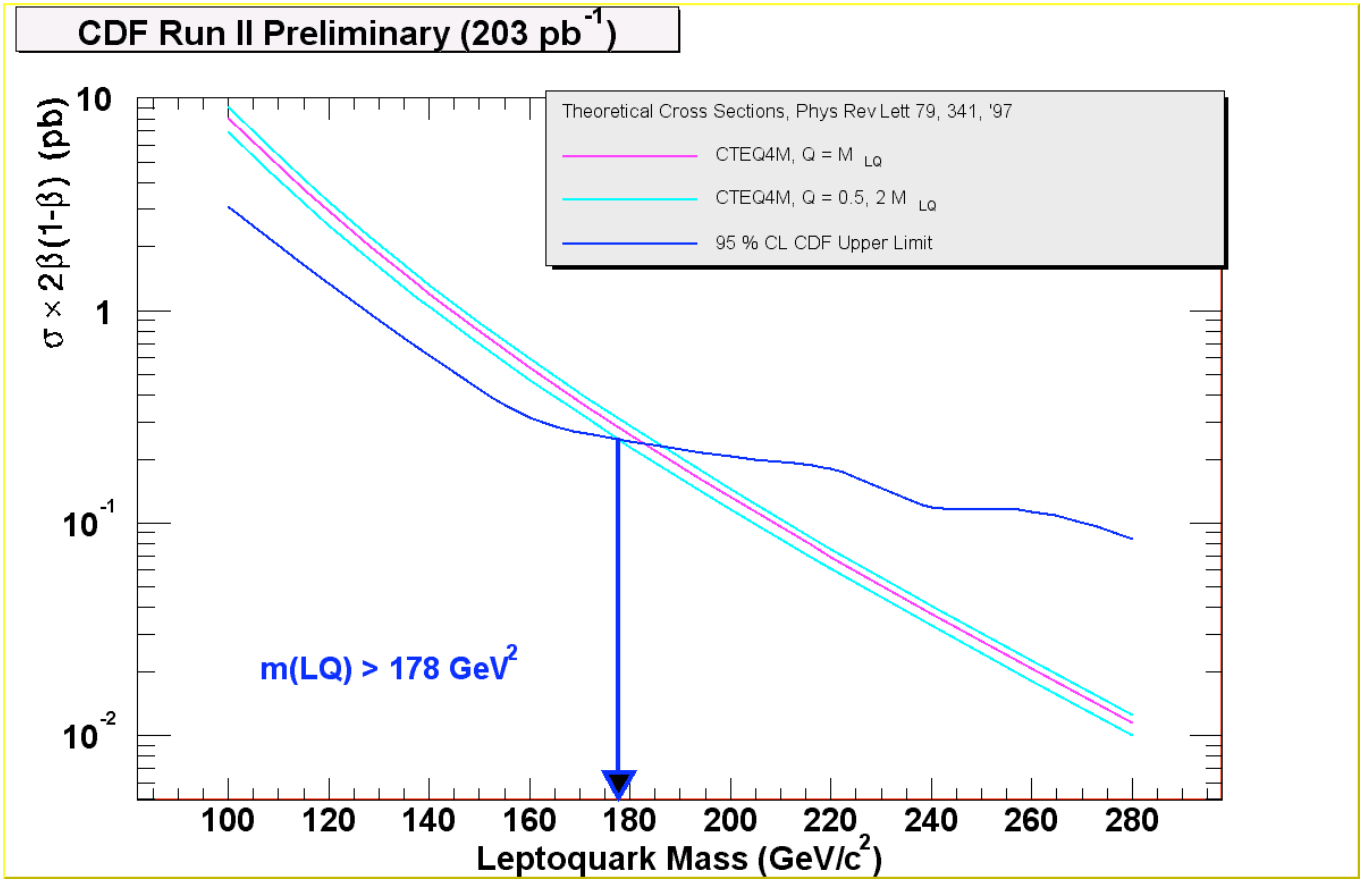
- Luminosity: 6%
- Acceptance
  - pdf 4.3% (from run I) - working on getting the new one
  - statistical error of MC 1.4%
  - jet energy scale (Level 3)
    - jets corrected for energy scale, time dependent and relative response
    - jet energy scaled of systematic uncertainty + 5% (energy scale + 5% data/MC adjustment); 0.4 to 1.0% from mass 100 to 280) 0.6% at 200 GeV/c^2
- Event vertex cut : 0.5%
- ISR/FSR - under investigation

Final acceptances and relative errors

Mass	A(LQ)	Stat	Sys
100	0.017	0.0019	0.001
120	0.038	0.002	0.002
140	0.073	0.004	0.005
160	0.107	0.004	0.008
180	0.139	0.005	0.010
200	0.165	0.005	0.012
220	0.195	0.005	0.014
240	0.210	0.006	0.015
260	0.226	0.006	0.168
280	0.249	0.006	0.018

Relative uncertainty
Inflated of ~10%

Cross section Limit



Conclusions

- A revision of the search for first generation LQ pair decaying into e□qq has been performed
  - New data sample - 203 pb-1
  - New final selection cut
  - Revised backgrounds
  - Cross check with W and W + 2 jets cross section
  - limit 178 GeV/c^2

Acceptances

Comparison with previous method (HEPG matching ele and ID from data)

	Kinematical eff	ID	Final
HEPG matching	0.173 ±0.005	0.945	0.163 ±0.005
MC ID	0.166±0.005	0.945/0.881	0.178 ±0.005

Acceptance w/ MetSig